CLAIMS

1. Apparatus comprising:

an electrode device, adapted to be coupled to a vagus nerve of a subject; and

a control unit, adapted to drive the electrode device to apply to the vagus nerve a current that reduces heart rate variability of the subject.

2. The apparatus according to claim 1, wherein the control unit is adapted to configure the current to substantially not reduce a heart rate of the subject.

3. The apparatus according to claim 1, wherein the control unit is adapted to configure the current to reduce the heart rate variability by at least 5% below a baseline thereof during a time period in which a heart rate of the subject is not reduced responsive to the current by more than 10% below a baseline thereof.

4. The apparatus according to claim 1, wherein the control unit is adapted to configure the current to effect a reduction of a heart rate of the subject while reducing the heart rate variability of the subject.

5. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device during exertion by the subject.

6. The apparatus according to claim 1, wherein the control unit is adapted to withhold driving the electrode device when the subject is not experiencing exertion.

7. The apparatus according to claim 1, wherein the control unit is adapted to configure the current to reduce a heart rate variability of the subject having a

characteristic frequency between about 0.15 and about 0.4 Hz.

8. The apparatus according to claim 1, wherein the control unit is adapted to configure the current to reduce a heart rate variability of the subject having a characteristic frequency between about 0.04 and about 0.15 Hz.

9. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device to apply the current with an amplitude of between about 2 and about 10 milliamps.

10. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device to apply the current in intermittent ones of a plurality of cardiac cycles of the subject.

11. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device to apply the current unsynchronized with a cardiac cycle of the subject.

12. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device responsive to a circadian rhythm of the subject.

13. The apparatus according to claim 12, wherein the control unit is adapted to drive the electrode device when the subject is awake.

14. The apparatus according to claim 12, wherein the control unit is adapted to withhold driving the electrode device when the subject is sleeping.

15. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device to

apply the current in a manner that reduces the heart rate variability by at least 10%.

16. The apparatus according to claim 15, wherein the control unit is adapted to drive the electrode device to apply the current in a manner that reduces the heart rate variability by at least 50%.

17. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device to apply the current in a manner that reduces a standard deviation of a heart rate of the subject within a time window.

18. The apparatus according to claim 17, wherein the control unit is adapted to drive the electrode device to apply the current in a manner that reduces a standard deviation of the heart rate of the subject within a time window longer than 10 seconds.

19. The apparatus according to claim 18, wherein the control unit is adapted to drive the electrode device to apply the current in a manner that reduces by at least about 10% the standard deviation of the heart rate within the time window longer than 10 seconds.

20. The apparatus according to claim 19, wherein the control unit is adapted to drive the electrode device to apply the current in a manner that reduces by at least about 50% the standard deviation of the heart rate within the time window longer than 10 seconds.

21. The apparatus according to claim 1, wherein the control unit is adapted to drive the electrode device to apply the current in respective pulse bursts in each of a plurality of cardiac cycles of the subject.

22. The apparatus according to claim 21, wherein the control unit is adapted to configure each pulse of each of the bursts to have a pulse duration of between about 0.1 and about 4 milliseconds.

23. The apparatus according to claim 22, wherein the control unit is adapted to configure each pulse of each of the bursts to have a pulse duration of between about 0.5 and about 2 milliseconds.

24. The apparatus according to claim 21, wherein the control unit is adapted to configure each of the bursts to have a pulse repetition interval of between about 2 and about 10 milliseconds.

25. The apparatus according to claim 24, wherein the control unit is adapted to configure each of the bursts to have a pulse repetition interval of between about 2 and about 6 milliseconds.

26. The apparatus according to claim 21, comprising a cardiac monitor, adapted to generate a cardiac signal, wherein the control unit is adapted to receive the cardiac signal, and to initiate the applying of each burst after a delay following detection of a feature of the cardiac signal.

27. The apparatus according to claim 26, wherein the control unit is adapted to initiate the applying of each burst after a delay of about 30 to about 200 milliseconds following an R-wave of the cardiac signal.

28. The apparatus according to claim 27, wherein the control unit is adapted to initiate the applying of each burst after a delay of about 50 to about 150 milliseconds following an R-wave of the cardiac signal.

29. The apparatus according to claim 21, wherein the control unit is adapted to configure at least one of the bursts to have between about 0 and about 20 pulses.

30. The apparatus according to claim 29, wherein the control unit is adapted to configure the bursts to have between about 1 and about 8 pulses during steady state operation.

31. The apparatus according to claim 1, comprising a heart sensor, configured to detect heart activity of the subject, and to generate a heart signal responsive thereto, wherein the control unit is adapted to:

receive the heart signal, and

responsive to receiving the heart signal, drive the electrode device to apply the current to the vagus nerve.

32. The apparatus according to claim 31, wherein the control unit is adapted to, responsive to receiving the heart signal, drive the electrode device to apply to the vagus nerve the current synchronized with a cardiac cycle of the subject.

33. The apparatus according to claim 31, wherein the control unit is adapted to, responsive to receiving the heart signal, drive the electrode device to apply to the vagus nerve the current unsynchronized with a cardiac cycle of the subject.

34. The apparatus according to claim 1, wherein the control unit is adapted to configure the current to reduce a heart rate of the subject.

35. The apparatus according to claim 34,

comprising a sensor, configured to detect the heart rate of the subject, and to generate a heart rate signal

responsive thereto,

wherein the control unit comprises an integral feedback controller that has inputs comprising the detected heart rate and a target heart rate,

and wherein the control unit is adapted to configure the current responsive to an output of the integral feedback controller, so as to reduce the heart rate of the subject toward the target heart rate.

36. The apparatus according to claim 35, wherein the target heart rate includes a target normal heart rate within a range of normal heart rates of the subject, and wherein the control unit is adapted to configure the current to reduce the heart rate of the subject toward the target normal heart rate.

37. The apparatus according to claim 1, wherein the control unit is adapted to configure the current to reduce the heart rate variability to treat a condition of the subject.

38. The apparatus according to claim 37, wherein the condition includes heart failure of the subject, and wherein the control unit is adapted to configure the current to reduce the heart rate variability by at least about 10% so as to treat the heart failure.

39. The apparatus according to claim 37, wherein the condition includes an occurrence of arrhythmia of the subject, and wherein the control unit is adapted to configure the current to reduce the heart rate variability by at least about 10% so as to treat the occurrence of arrhythmia.

40. The apparatus according to claim 37, wherein the condition includes atrial fibrillation of the subject,

and wherein the control unit is adapted to configure the current to reduce the heart rate variability so as to treat the atrial fibrillation.

41. A method comprising applying to a vagus nerve of a subject a current that reduces heart rate variability of the subject.

42. The method according to claim 41, wherein applying the current comprises configuring the current to substantially not reduce a heart rate of the subject.

43. The method according to claim 41, wherein applying the current comprises configuring the current to reduce the heart rate variability by at least 5% below a baseline thereof during a time period in which a heart rate of the subject is not reduced responsive to the current by more than 10% below a baseline thereof.

44. The method according to claim 41, wherein applying the current comprises configuring the current to effect a reduction of a heart rate of the subject while reducing the heart rate variability of the subject.

45. The method according to claim 41, wherein applying the current comprises detecting exertion by the subject and applying the current during the exertion.

46. The method according to claim 41, wherein applying the current comprises:

detecting whether the subject is experiencing exertion; and

withholding applying the current when the subject is not experiencing exertion.

47. The method according to claim 41, wherein applying the current comprises configuring the current to reduce

a heart rate variability of the subject having a characteristic frequency between about 0.15 and about 0.4 Hz.

48. The method according to claim 41, wherein applying the current comprises configuring the current to reduce a heart rate variability of the subject having a characteristic frequency between about 0.04 and about 0.15 Hz.

49. The method according to claim 41, wherein applying the current comprises applying the current with an amplitude of between about 2 and about 10 milliamps.

50. The method according to claim 41, wherein applying the current comprises applying the current in intermittent ones of a plurality of cardiac cycles of the subject.

51. The method according to claim 41, wherein applying the current comprises applying the current unsynchronized with a cardiac cycle of the subject.

52. The method according to claim 41, wherein applying the current comprises applying the current responsive to a circadian rhythm of the subject.

53. The method according to claim 52, wherein applying the current comprises applying the current when the subject is awake.

54. The method according to claim 52, wherein applying the current comprises withholding applying the current when the subject is sleeping.

55. The method according to claim 41, wherein applying the current comprises applying the current in a manner that reduces the heart rate variability by at least 10%.

56. The method according to claim 55, wherein applying the current comprises applying the current in a manner that reduces the heart rate variability by at least 50%.

57. The method according to claim 41, wherein applying the current comprises applying the current in a manner that reduces a standard deviation of a heart rate of the subject within a time window.

58. The method according to claim 57, wherein applying the current comprises applying the current in a manner that reduces a standard deviation of the heart rate of the subject within a time window longer than 10 seconds.

59. The method according to claim 58, wherein applying the current comprises applying the current in a manner that reduces by at least about 10% the standard deviation of the heart rate within the time window longer than 10 seconds.

60. The method according to claim 59, wherein applying the current comprises applying the current in a manner that reduces by at least about 50% the standard deviation of the heart rate within the time window longer than 10 seconds.

61. The method according to claim 41, wherein applying the current comprises applying the current in respective pulse bursts in each of a plurality of cardiac cycles of the subject.

62. The method according to claim 61, wherein applying the current comprises configuring each pulse of each of the bursts to have a pulse duration of between about 0.1 and about 4 milliseconds.

63. The method according to claim 62, wherein applying the current comprises configuring each pulse of each of

the bursts to have a pulse duration of between about 0.5 and about 2 milliseconds.

64. The method according to claim 61, wherein applying the current comprises configuring each of the bursts to have a pulse repetition interval of between about 2 and about 10 milliseconds.

65. The method according to claim 64, wherein applying the current comprises configuring each of the bursts to have a pulse repetition interval of between about 2 and about 6 milliseconds.

66. The method according to claim 61, comprising receiving a cardiac signal, wherein applying the current comprises initiating the applying of each burst after a delay following detection of a feature of the cardiac signal.

67. The method according to claim 66, wherein applying the current comprises initiating the applying of each burst after a delay of about 30 to about 200 milliseconds following an R-wave of the cardiac signal.

68. The method according to claim 66, wherein applying the current comprises initiating the applying of each burst after a delay of about 50 to about 150 milliseconds following an R-wave of the cardiac signal.

69. The method according to claim 61, wherein applying the current comprises configuring at least one of the bursts to have between about 0 and about 20 pulses.

70. The method according to claim 69, wherein applying the current comprises configuring the bursts to have between about 1 and about 8 pulses during steady state operation.

71. The method according to claim 41, comprising detecting heart activity of the subject, and generating a heart signal responsive thereto, wherein applying the current comprises:

receiving the heart signal; and

responsive to receiving the heart signal, applying the current to the vagus nerve.

72. The method according to claim 71, wherein applying the current comprises:

synchronizing the current with a cardiac cycle of the subject, responsive to receiving the heart signal; and

applying the synchronized current to the vagus nerve.

73. The method according to claim 71, wherein applying the current comprises applying the current to the vagus nerve, (a) responsive to receiving the heart signal, and (b) unsynchronized with a cardiac cycle of the subject.

74. The method according to claim 41, wherein applying the current comprises configuring the current to reduce a heart rate of the subject.

75. The method according to claim 74, comprising detecting the heart rate of the subject, wherein applying the current comprises configuring the current so as to reduce the heart rate of the subject toward a target heart rate, responsive to an output of an integral feedback controller whose inputs comprise the detected heart rate and the target heart rate.

76. The method according to claim 75, wherein the target heart rate includes a target normal heart rate within a range of normal heart rates of the subject, and

wherein applying the current comprises configuring the current so as to reduce the heart rate of the subject toward the target normal heart rate.

77. The method according to claim 41, wherein applying the current comprises configuring the current to reduce the heart rate variability so as to treat a condition of the subject.

78. The method according to claim 77, wherein the condition includes heart failure of the subject, and wherein applying the current comprises configuring the current to reduce the heart rate variability by at least about 10% so as to treat the heart failure.

79. The method according to claim 77, wherein the condition includes an occurrence of arrhythmia of the subject, and wherein applying the current comprises configuring the current to reduce the heart rate variability by at least about 10% so as to treat the occurrence of arrhythmia.

80. The method according to claim 77, wherein the condition includes atrial fibrillation of the subject, and wherein applying the current comprises configuring the current to reduce the heart rate variability so as to treat the atrial fibrillation.